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FINAL 01 Dec 90 TO 28 Feb 91

Scanned Probe Microscopies: STM and Beyond

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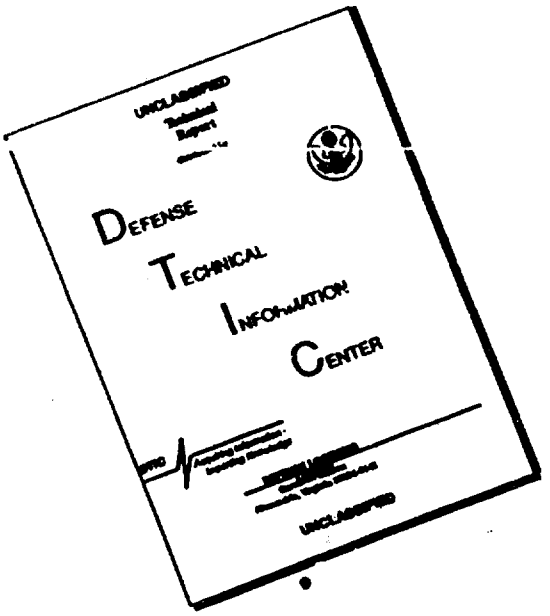

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Scanned Probe Microscopies: STM and Beyond

A conference organized under the auspices of the

Engineering Foundation, New York City
(Director: Charles V. Freiman)

January 6-11, 1991

Santa Barbara, CA (Sheraton Hotel)

Chairman

H. Kumar Wickramasinghe, IBM Research (Yorktown)

Co-chairman

F. Alan McDonald, IBM Research (Yorktown)

Organizing Committee

Hans Güntherodt - University of Basel
Paul Hansma - University of California, Santa Barbara
James Murday - Naval Research Lab
Calvin Quate - Stanford University
Heinrich Rohrer - IBM Research (Zurich)
Clayton Teague - NIST

Sponsoring organizations

Engineering Foundation
IBM Corporation
Air Force Office of Scientific Research
Office of Naval Research
National Science Foundation

Tuesday (Jan. 8)

8:15 a.m. **Applications in biology I**

8:15 Contrast and conduction in STM images of biomolecular complexes
S.M. Lindsay, U. Arizona

8:50 Toward sequencing DNA
H. Hansma, U. Calif., Santa Barbara

9:25 Imaging DNA with AFM
H.E. Gaub, Technical U., Munich

10:00 *Coffee break*

10:15 UHV imaging of DNA
M.G. Youngquist, Calif. Inst. Tech.

10:50 Imaging of single-stranded DNA
A. Cricenti, CNR, Frascati

11:25 Imaging of RNA polymerase
C. Bustamente, U. New Mexico

12:00 Imaging the DNA-base adenine adsorbed on graphite
W.J. Siekhaus, Lawrence Livermore Lab

7:30 p.m. **Applications in biology II**

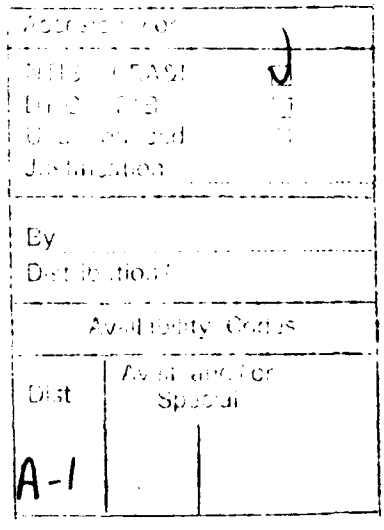
7:30 Molecular imaging with STM
D.J. Thomson, U. Manitoba

8:05 Imaging of cell sheaths
M.H. Jericho, Dalhousie U.

8:40 Imaging of membrane proteins
J.K.H. Hörber, Max-Planck-Inst., Heidelberg

9:15 Imaging of enzymes
D.F. Evans, U. Minnesota

9:50 Cyto-keratine protein studies using STM
D. Sarid, U. Arizona



Wednesday (Jan. 9)

8:15 a.m. **Applications in chemistry**

8:15 Scanning electrochemical microscopy
A.J. Bard, U. Texas

8:55 Electrode-solution interface
N.S. Lewis, Calif. Inst. Tech.

9:35 Atomic-resolution electrochemistry
A. Gewirth, U. Illinois

10:15 *Coffee break*

10:30 Imaging of reactive sites
M. Balooch, Lawrence Livermore Lab

11:10 Probing and inducing chemistry with the STM
P. Avouris, IBM Yorktown

11:50 Investigation of polymer crystallites on graphite by STM
G. Stupian, Aerospace Corp.

Fri (Jan. 11)

8:15 a.m. **High-resolution magnetic imaging**

8:15 Tunneling of spin-polarized electrons
H.-J. Guntherodt, U. Basel

8:55 Analysis of magnetic domains by MFM and STM
U. Hartmann, KFA Julich

9:35 Applications of MFM
D. Rugar, IBM Almaden

10:15 *Coffee break*

10:30 a.m. **Issues and opportunities - panel**

Discussion leaders:

Novel measurements
P. Hansma, Professor of Physics, U. Calif., Santa Barbara

Biostructures
W. Baumeister, Director, Max-Planck I. for Biochemistry

Nano-technology
H. Craighead, Director, National Nanofabrication Facility

Metrology
C. Teague, Group leader, Micro-metrology, NIST

R. Bate, TI Fellow, Texas Instruments
E. Cox, Professor of Biophysics, Princeton U.
V. Elings, President, Digital Instruments
R. Melcher, Director, Physical Sciences, IBM Yorktown
J. Murday, Superintendent, Chemistry Div., Naval Res. Lab
D. Whitehouse, Director, Centre for Microengineering and Metrology, U. Warwick
E. Zeitler, Director, Electron Microscopy, Fritz Haber I.

1:00 p.m. *Lunch*

Report on

ENGINEERING FOUNDATION CONFERENCE

on

Scanned Probe Microscopies: STM and Beyond

Sheraton Hotel and Spa, Santa Barbara CA, 6-11 January 1991

GENERAL OVERVIEW

This conference was, with a few exceptions, of very high quality. Attendance, thanks to several walk-ins, was higher than expected. The intellectual content was outstanding, with a great deal of new and recent material being presented. Audience participation was excellent, but the programming left insufficient time for discussion. The weather was moderately cool with a mix of sun and clouds and 24 hours of heavy rain gratefully received by the Californians. Attention from the hotel was very satisfactory. Based on a virtually 100% consensus, the prospect for a second conference 2 years hence is good, although the present organizers were not very helpful in identifying a new secretariat—I have a few names to explore, but will have to start pretty much from scratch.

Attendance was 75, comprising 51 U.S., 8 Germany, 4 France, 3 Italy, 3 UK, 2 Canada, 2 Netherlands, 1 Switzerland and 1 Japan. There were 38 academic, 12 industry and 25 from research labs—including 7 from IBM. The Chairman was Kumar Wickramasinghe and the Cochair was Alan McDonald, both of of IBM Yorktown.

CONFERENCE PROGRAM

The program, enthusiastically received, was at very high level and reported much new theoretical and applied research. Many of conferees knew each other, which got the conference off to a quick start. With some exceptions, the program was well controlled, although six to seven intensive and detailed papers per session did not allow much time for discussion, leading to numerous complaints. Slides were exceptionally good. Many overhead transparencies were impossibly detailed and illegible—too much material and too small text and legends. Perhaps our Chairman's Manual should urge both preview and some standards for transparencies.

The program dealt with an array of scanning probe and other microscopy techniques based on various physical and chemical properties. Some of them are:

- Scanning Tunneling Microscopy STM
- Scanning Electrochemical Microscopy SEM
- Scanning Capacitance Microscopy SCM
- Scanning Force Microscopy SFM
- Atomic Force Microscopy AFM
- Magnetic Force Microscopy
- Photon STM
- Ballistic Electronic Microscopy
- Photo Tunneling Microscopy
- Evanescent Field Optical Microscopy

as well as the Scanning Electron Microscope and the Scanning Near-Field Optical Microscope, which I think are not probe types. Some of these techniques may prove to be too limited in application and may wither away over the next two years until the next conference.

The "mother" of most of these techniques is the Scanning Tunneling Microscope. In simplistic terms, scanning refers to the ability to look, point by point, at a field a few microns in size containing objects or surface features as small as a nanometer, but more often 10nm or larger. The instrument uses a sharply pointed probe to induce, usually with a fixed voltage, a flow of electrons between the probe tip and the object observed and records the current or rate of flow of electrons as a function of the topography as the tip is moved over microscopic intervals. In some STMs, the probe is at the end of a tube and the tube is displaced by piezoelectric cells, moving the tip. Tunneling is the establishment of the electron flow. The electrical data can be processed by computer graphics into images of the field to produce a physical picture of the object or topography. The graphics are stupendous, using advanced techniques for coloring and side-on illumination. I came away, however, with considerable question whether the images, especially in biological applications, show what we think they show or hope to see, but the proponents did not seem to be bothered by this. In images purporting to show a DNA double helix, it took a lot of imagination—no pun intended—for me to see a helix. That does not dilute my wonderment, however. It is possible now to "see" individual molecules and we are on the verge of being able to pick up, relocate and deposit individual atoms, which suggests exciting possibilities.

Once the various scanning methods and localized electronic effects had been described, sessions were devoted to application to biology, chemistry and nanostructures. The biology was fascinating, although scanning of DNA and RNA seemed to me to be a bit overworked. The chemistry portion was more straightforward and it was generally agreed that STM is a powerful tool for studying chemistry. The nanostructure technology is mainly device-oriented—submicron electronic devices, lithography, material and surface modification, as well as nanometrology. Other details dealt with things like contact and non-contact probes, probe insulation, magnetic lenses and surface damage.

SUPPLEMENTARY

INFORMATION

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April 4, 1992

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RE: Grant No. N000014-91-J-1164

Dear Sir or Madam:

In our letter of January 14, 1992 we sent you a copy of the proceedings of the Engineering Foundation Conference on "Scanned Probe Microscopies: STM and Beyond".

Enclosed you will find the Report Documentation Page. We are sorry for any inconvenience we may have caused by not sending it with the proceedings.

Sincerely,

Charles V. Freiman
Director

CVF/jms

Enc.

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16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	STM, SEM, SCM, SFM, AFM, Magnetic Force Microscopy, Photon STM, Ballistic Electronic Microscopy, Photo Tunneling Microscopy, Evanescent Field Optical Microscopy

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

The proceedings of the conference "Scanned Probe Microscopies: STM and Beyond" held January 1991 in Santa Barbara, CA deal with an array of scanning probe and other microscopy techniques. The major subject areas are:

Scanned Probes
Localized Electronic Effects
Applications in Biology I
Applications in Biology II
Applications in Chemistry
Spectroscopy
Applications in Nano-Technology I
Applications in Nano-Technology II
High-Resolution Magnetic Imaging
Issues and Opportunities

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